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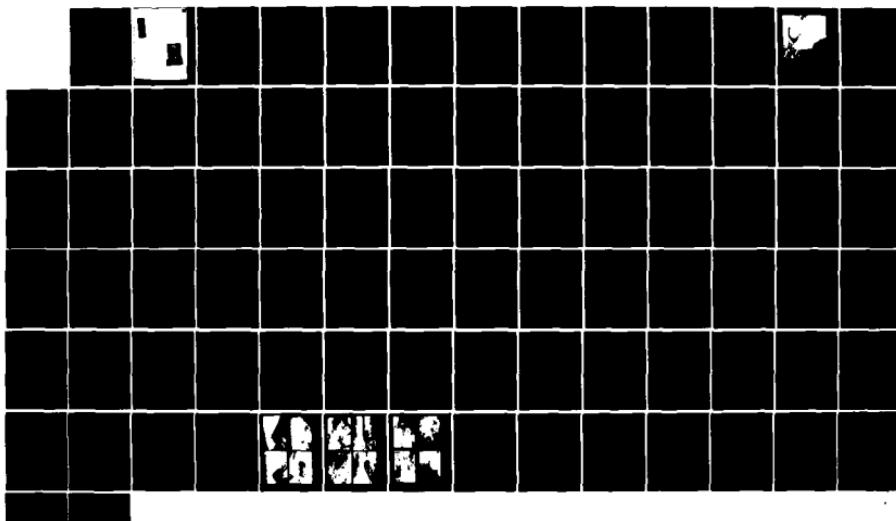
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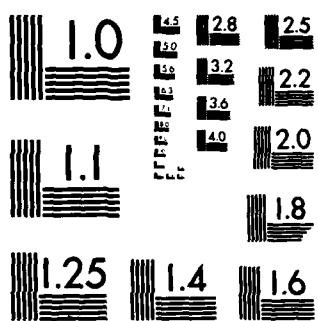
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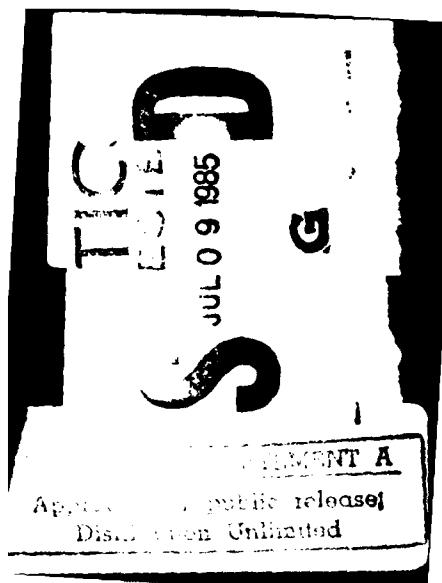
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The dam consists of a main dam, a dike and a spillway. The dam is an earth embankment 620 ft. long and 34 ft. high. The dam is assessed to be in overall good condition. No evidence of instability or other major problem was uncovered. The dam has received conscientious and knowledgeable maintenance, with a few exceptions. The ham is in the significant hazard class.		

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DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02154

REPLY TO
ATTENTION OF:

NEDED

Honorable Meldrim Thomson, Jr.
Governor of the State of New Hampshire
State House
Concord, New Hampshire 03301

DEC 1

Dear Governor Thomson:

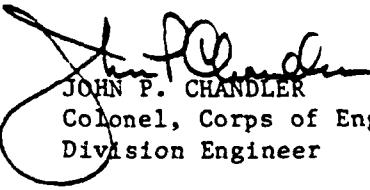
I am forwarding to you a copy of the Tower Hill Pond Dam Phase I Inspection Report, which was prepared under the National Program for Inspection of Non-Federal Dams. This report is presented for your use and is based upon a visual inspection, a review of the past performance and a brief hydrological study of the dam. A brief assessment is included at the beginning of the report. I have approved the report and support the findings and recommendations described in Section 7 and ask that you keep me informed of the actions taken to implement them. This follow-up action is a vitally important part of this program.

A copy of this report has been forwarded to the Water Resources Board, the cooperating agency for the State of New Hampshire. In addition, a copy of the report has also been furnished the owner, Manchester Water Works, 281 Lincoln Street, Manchester, New Hampshire 03101.

Copies of this report will be made available to the public, upon request, by this office under the Freedom of Information Act. In the case of this report the release date will be thirty days from the date of this letter.

I wish to take this opportunity to thank you and the Water Resources Board for your cooperation in carrying out this program.

Sincerely yours,


JOHN F. CHANDLER
Colonel, Corps of Engineers
Division Engineer

Incl
As stated

TOWER HILL POND DAM

NH 00219

MERRIMACK RIVER BASIN
AUBURN, NEW HAMPSHIRE

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

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PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam Tower Hill Pond Dam
State Located New Hampshire
County Located Rockingham
City or Town Auburn
Stream Maple Falls Brook
Date of Inspection 6/12/78 and 7/5/78

Brief Assessment

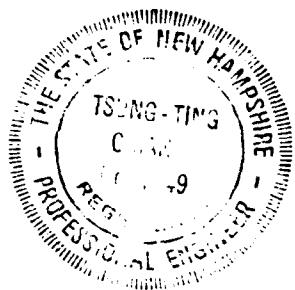
Tower Hill Pond Dam consists of three structures, a main dam, a dike, and a spillway, on the south end of Tower Hill Pond in Auburn, N.H. The main dam is an earth embankment 620 feet long and 34 feet high with an intake control tower and 30" discharge conduit for regulating flow. The dike is an earth embankment 600 feet long and 22 feet high. The spillway is a concrete and stone masonry ogee weir, 250 feet long with a gross height to top of dam of 5 feet. The project was built in 1939-40 and is part of the water supply for the City of Manchester.

Tower Hill Pond Dam is assessed to be in overall good condition. No evidence of instability or other major problem was uncovered. The dam has received conscientious and knowledgeable maintenance, with a few exceptions. Some repair and remedial work is recommended.

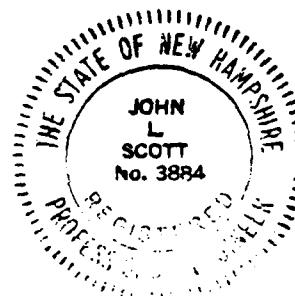
The spillway is adequate to pass a test flood equal to the full probable maximum flood (PMF) with about one foot to spare. Overtopping potential, except for wave action, is judged as very low. The dam is in the "Significant" hazard class. It is upstream from the village of Auburn and, farther downstream, Massabesic Lake Dam, a high hazard structure.

Recommended work includes repairs to three gates, plugging a minor leak through the spillway, and clearing the spillway area of flow obstructions. These recommendations and remedial work are described in Section 7 and should be implemented by the owner within 24 months after receipt of this Phase I Report.

WHITMAN & HOWARD, INC.



T. T. Chiang, Ph.D., P.E.



John L. Scott

John L. Scott, P.E.

This Phase I Inspection Report on Tower Hill Pond Dam has been reviewed by the undersigned Review Board members. In our opinion, the reported findings, conclusions, and recommendations are consistent with the Recommended Guidelines for Safety Inspection of Dams, and with good engineering judgment and practice, and is hereby submitted for approval.

Charles G. Tiersch

CHARLES G. TIERSCH, Chairman
Chief, Foundation and Materials Branch
Engineering Division

Fred J. Ravens Jr.

FRED J. RAVENS, Jr., Member
Chief, Design Branch
Engineering Division

Saul Cooper

SAUL COOPER, Member
Chief, Water Control Branch
Engineering Division

APPROVAL RECOMMENDED:

Joe B. Fryar

JOE B. FRYAR
Chief, Engineering Division

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I Investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fraction thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aide in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

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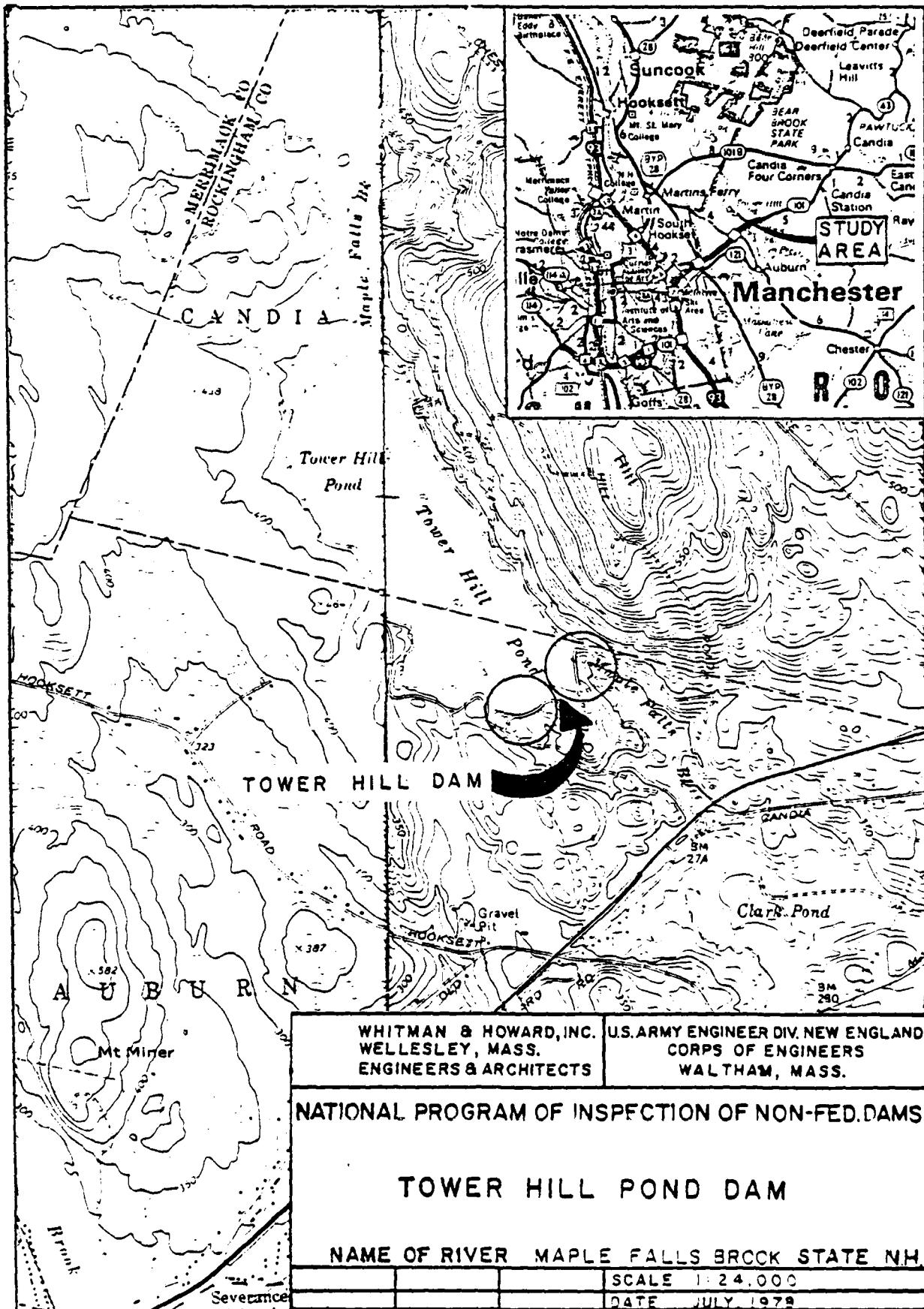
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TOWER HILL POND DAM

Auburn, N.H.

Approx. Scale 1"=280'



PHASE I INSPECTION REPORT

TOWER HILL POND DAM

NH 00219

SECTION 1

PROJECT INFORMATION

1.1 General

a. Authority

Public Law 92-367, August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a national program of dam inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region. Whitman & Howard, Inc. has been retained by the New England Division to inspect and report on selected dams in the State of New Hampshire. Authorization and notice to proceed was issued to Whitman & Howard, Inc. under a letter of May 1, 1978 from Ralph T. Garver, Colonel, Corps of Engineers. Contract No. DACW33-78-C-0313 has been assigned by the Corps of Engineers for this work.

b. Purpose

- (1) Perform technical inspection and evaluation of non-Federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by non-Federal interests.
- (2) Encourage and assist the States to initiate quickly effective dam safety programs for non-Federal dams.
- (3) To update, verify and complete the National Inventory of Dams.

1.2 Description of Project:

a. Location

The dam is located at the south end of Tower Hill Pond in the Town of Auburn, N.H. It appears on the USGS quadrangle "Candia, N.H."

b. Description of Dam and Appurtenances

Tower Hill Pond Dam is actually three separate structures, an earth dam with gatewell outlet works, a dike and a spillway. The sites are about 1,000 feet apart.

The main dam is an earth embankment with "selected impervious hardpan" in the upstream zone, and "porous hardpan" in the remainder. A cutoff trench is incorporated in the impervious zone. A thick layer of riprap covers the upstream face. The base was apparently built upon existing ground after stripping of loam and boulders; the cutoff was not apparently designed to extend to ledge.

There is a thorough network of gravel drains under the base of the dam. The gatewell is of reinforced concrete, 6 ft. x 6 ft. interior plan dimensions and 32' deep from the superstructure floor to the bottom. The bottom of the well is 29 ft. below the spillway crest and 34 ft. below the top of the dam. There are three 2' x 3' gated openings - one at the bottom, one 8-1/2' above the bottom, and one 16-1/2' above the bottom. A 30' ungated discharge pipe leads from the gate well through the dam to a stone masonry discharge channel. The gatewell superstructure is of wood frame construction, and the 48' long catwalk is of wood planking on steel beams with one concrete midspan support pier.

The embankment for the dike is similar to that for the main dam, but the impervious zone is augmented with puddled clay, and the west end is on ledge. This structure is nearly the same length as the main dam, though not as high.

The spillway is located to the west of the dike, between two ledge outcroppings. It is a low sturdy-looking structure of concrete and stone masonry. The crest is at elevation 320.95 feet msl, and has a length of 250' with 8 piers 2' high. There are provisions for flashboards, though none have been used recently.

c. Size Classification

Size classification of all dams is based on the following table:

<u>Category</u>	<u>Storage (Ac-Ft)</u>	<u>Height (Ft)</u>
Small	less than 1,000	AND less than 40
Intermediate	between 1,000 & 50,000	OR between 40 & 100
Large	over 50,000	OR over 100

The storage capacity of 3,960 ac-ft, places Tower Hill Pond Dam at the lower end of the "Intermediate" category.

d. Hazard Classification

Tower Hill Pond Dam discharges to Maple Falls Brook which runs southerly under Route 101 to Clark Pond, thence into Massabesic Lake via Sucker Brook past the village of Auburn, 2-1/2 miles downstream. Three highway bridges, a railroad bridge, and a few scattered houses and buildings lie in vulnerable positions.

Failure of Tower Hill Pond Dam would increase the level of Massabesic Lake on the order of one foot. Should this occur when lake level is already high, such as during general flooding, this extra foot would threaten Massabesic Lake Dam, a high hazard structure with relatively low spillway capacity.

The above considerations place Tower Hill Pond Dam in the "Significant" hazard classification (middle category of three).

e. **Ownership** - The dam was built, and is owned today by, the Manchester Water Works, the publicly-owned water supply utility for the City of Manchester.

f. **Operator** - Ethan Howard
Manchester Water Works
281 Lincoln Street
Manchester, NH 03101
603/668-3830

g. **Purpose of Dam**

Tower Hill Pond Dam was built by the Manchester Water Works to improve the quality and quantity of the Manchester water supply. Tower Hill Pond is on the watershed of Massabesic Lake, the source of water supply for the City of Manchester.

h. **Design and Construction History**

The dam was built in 1939-40 on the site of a very small dike and flashboard structure whose impoundment was small in comparison to the present Tower Hill Pond. This structure was apparently overtopped in the 1938 flood and was demolished during the construction of the present dam.

The dam was designed by P.A. Shaw, then superintendent of the Water Works, and constructed under the Federal WPA labor program. Its purpose was to store spring run-off and to reduce color and bacteria. The original design plans called for a timber crib spillway, but this was scrapped in favor of the more substantial earth dike and concrete spillway now in existence.

No significant post-construction changes have ever been made and there has been no reported damage or problems.

i. **Normal Operational Procedure**

In the fall, the top intake gate is opened, and kept open through the winter. After the

spring thaw, the gate is closed and the pond fills, eventually flowing over the spillway. In summer if the pool drops below the spillway, one of the gates is opened slightly to keep flow in the channel..

1.3 Pertinent Data

a. Drainage Area

The drainage area at the dam is 12.5 sq. mi. There is one small dam upstream, though it is not very threatening. The terrain is hydraulically classified as flat. All property surrounding Tower Hill Pond is owned by the Manchester Water Works and water recreation is prohibited.

b. Discharge at Damsite

- (1) Maximum known flood at damsite - Not recorded.
- (2) Discharge pipe at top of dam pool elev. - 160 cfs
- (3) Discharge pipe at spillway pool elev. - 140 cfs
- (4) Ungated spillway capacity at maximum pool elev. - 10,340 cfs
- (5) Total capacity of spillway plus discharge pipe - 10,500 cfs

c. Elevation (ft. above MSL)

- (1) Top Dam - 325.95 (both main dam and dike)
- (2) Maximum pool-design surcharge - 323.5 (equals top dam minus 2.5' wave height)
- (3) Full flood control pool - N/A
- (4) Recreation pool - Not used for recreation

(5) Spillway crest - 320.95

(6) Centerline intake gates - 310.45 upper
302.45 middle
293.95 lower

Upstream invert discharge pipe - 291.95

Downstream invert discharge pipe -
290.95

(7) Streambed at centerline of dam - approx.
291

(8) Maximum tailwater - Unknown

d. Reservoir

(1) Length of maximum pool - approx. 5,600
ft.

(2) Length of pool at normal level - 5,500
ft.

(3) Length of flood control pool - N/A

e. Storage (acre-ft.)

(1) Spillway Crest - 3,960

(2) Flood Control Pool - N/A

(3) Design Surcharge - 4,480

(4) Top of Dam - 5,020

f. Reservoir Surface (acres)

(1) Spillway Crest - 202

(2) Flood Control Pool - N/A

(3) Design Surcharge - 213

(4) Top of Dam - 222

g. Dam

	<u>Main Dam</u>	<u>Dike</u>
(1) Type	Earth fill gravity	Earth Fill gravity
(2) Length	620 feet	600 feet
(3) Height	34 feet	22 feet
(4) Top Width	15 feet	12 feet
(5) Side Slopes	upstream - 2:1 downstream - 2:1	upstream - 2.5:1 downstream - 2:1
(6) Zoning*	Impervious zone on upstream side. Rock toe drain.	Impervious zone in middle. Rock toe drain.
(7) Impervious Core*	"hardpan"	"hardpan & puddled clay"
(8) Cutoff*	trench	trench plus concrete
(9) Grout Curtain	None shown on design	None shown on design

*See Sections in Appendix B.

h. Diversion and Regulating Tunnel

- (1) Type - 30" C.I. pipe
- (2) Length - 160' from gatewell thru dam to discharge channel
- (3) Closure - None. Intake portals are gated.
- (4) Access - Ladder in gatewell
- (5) Regulating Facilities - Flow regulated by gates on intake ports of gatehouse

i. Spillway

- (1) Type - Concrete and stone masonry- unusual design- See sections in Appendix B.

- (2) Length of weir - 250 ft.
- (3) Crest elevation - 320.95
- (4) Gates - None. Provision for 1' high flashboards - not used.
- (5) U/S Channel - None. Spillway on lakeshore.
- (6) D/S Channel - Natural swale, ledge and boulders, somewhat overgrown.

j. Regulating Outlets

- (1) Description - Gate well 6' x 6' interior plan dimensions, 32 ft. deep from gatehouse floor to bottom. Wood frame gatehouse atop gate well.
- (2) Intake Portals - Three, 2' x 3' size. One at the bottom, second 8.5' above the bottom, third 16.5' above the bottom.
- (3) Closure - Sluice gates operated manually from gatehouse above.
- (4) Access - Wood plank catwalk, 48' long, on steel frame from dam crest. One concrete midspan support.

SECTION 2: ENGINEERING DATA

2.1 Design

The main dam was designed as an earth fill gravity dam. Soils were borrowed from nearby pits and the structure was zoned impervious upstream and pervious downstream. Liberal use of gravel underdrains was designed in, and there is a substantial rock-fill toe drain. Riprap covers the upstream face and was obtained from the dam excavation plus the remainder borrowed from pits.

The design drawings show no filter or transition sections between the various zones, other than calling for the "lapping" of layers during construction.

The intake gatewell has three inlets at different elevations presumably so water quality could be selected during times of stratifications in the reservoir.

The dike and spillway were designed after the main dam. The dike is similar in construction to the main dam, but the zoning is different probably because of the existence of ledge. The spillway structure is a curious design, probably to avoid blasting ledge and using much concrete. The entire project shows the avoidance of the use of a large amount of concrete.

The design notes and computations available show a considerable concern for proper hydraulic design and a working knowledge of hydrology. There were several redesigns involved before settling on the dike and spillway configuration. First, there was a temporary timber structure drawn up, then a two piece 150' long spillway, and finally the configuration which was actually constructed.

Both the engineering design and the construction supervision were performed by the Manchester Water Works, and labor was supplied under the Federal WPA program. There was apparently concern about the availability of labor and how far the project could go, as the plans show an intermediate level at which work would stop if they could not go all

the way. Things must have worked out as the existing dam is at the full size planned.

2.2 Construction

Few useful construction records exist which relate to an evaluation in the present time. However, since it was a WPA project the specs go into much more detail regarding construction methods than is usual (See Appendix B). The construction methods mentioned in the specifications are sound, though much was left to the discretion of the chief engineer on site. No records exist as to whether the methods were followed.

2.3 Operation

No operation records were uncovered, and the Manchester Water Works does not now keep written records on the dam operation.

2.4 Evaluation

- a. Availability - Full sets of construction plans and specifications are available, as well as design notes and computations, particularly hydrologic data in creating the pond. Most of the information is in the possession of the Manchester Water Works, and the N.H. Water Resources Board has but a small amount of data.

There are no data on soils other than generalized descriptions, and no boring logs or other geologic information.

There are no useful construction reports or records.

There are no operation records, although it is known that no distress has ever been reported.

- b. Adequacy - The design information is quite good, but the absence of construction and operation information limits their usefulness. Much of the evaluation rests with the visual observation.

- c. Validity - The validity of the available data seems quite good, as the existing conditions match the plans as near as can be visually determined.

SECTION 3: FINDINGS

3.1 Findings

a. General

The site is obviously well cared for, and the area is well patrolled. The embankment slopes have been kept clear of trees and shrubs, of particular importance in earth fill structure particularly those without concrete core walls. The field notes are contained in the inspection check list, in Appendix A.

b. Dam

(1) Main Dam

The roadway across the crest is in poor condition with numerous potholes. Some portions of the cut stone barrier on the upstream edge of roadway have been dislodged. Several areas of the wood guardrail on the downstream edge of the roadway are missing, allowing for motorcycle traffic up the downstream face. This traffic has worn two considerable paths which have been aggravated by surface erosion. Riprap shows some settlement in a few places although not serious. The riprap varies in size, with the smallest appearing to be too small. The downstream face is completely clear of trees and shrubs and there are no stumps or other evidence that growth was ever allowed. Except for a few bare spots (apparently caused by some sort of recent plowing or scraping), the downstream face is covered with a dense growth of grass. A few irregular areas appear just above the toe of the downstream face, probably the result of soil percolating into the voids in the rock toe. It is not a recent occurrence by evidence of the grass growth and seems to have stabilized. Some areas at the toe show some sort of man-made mechanical disturbance, as from a snow plow. The toe drain outlet is active. Flow is distinctly reddish, indicating a high iron content. There was no evidence of boils or seeps. One small wet area was found 50 feet downstream of the toe.

(2) Dike

The roadway across the crest is in poor condition with numerous potholes somewhat worse than the main dam roadway. Some portions of the cut stone barrier on the upstream edge of roadway have been dislodged. Riprap appears to be uniformly small, and the areas of settlement are slightly worse than similar areas on the main dam. The downstream face is completely clear of trees and shrubs and there are no stumps or other evidence that indicate this was ever allowed. There are no motorcycle or erosion paths, and the downstream face is nicely covered with a dense growth of grass.

There are the same surface irregularities at the toe as on the main dam - again probably this is a stable condition. There was no evidence of boils, seeps, or wet spots.

c. Appurtenant Structures

(1) Main Dam

The gate well and house appear sound and stable, although the gate well was not inspected below the water level. The gate house door is of particularly sturdy construction. The gates themselves are in poor condition - the upper gate leaks and jams, the middle gate does not leak but is quite difficult to work, and the operator declined to work the bottom gate as it has not been used in quite awhile. The wood floor of the gate house is not strong enough to absorb the thrust from the gates, as when the gates stick, the cranking action moves the floor boards instead of the gates. The catwalk is missing one plank, and is vertically misaligned at the midspan support. The misalignment appears to be the cause of poor bearing design and not from settlement or other structural movement.

The outlet channel for the 30" discharge pipe and toe drains is of stone masonry construction and is in good condition.

(2) Dike

A stone lined ditch, much smaller than that of the main dam, was discovered in the woods about 40' downstream from the deepest part of the dike. It is apparently the outlet for the toe drains of the dike, but does not show on the plans. The channel had standing water and was not flowing.

(3) Spillway

The concrete surfaces of the spillway structure are in good condition with a normal amount of erosion and no noticeable spalling of other surface problems. Stubs are all that remain of the flashboard pins, as flashboards are no longer employed. A considerable amount of sand and gravel has accumulated against the upstream side of the spillway, and vegetation is growing in this material at the west end of the spillway. A small leak was discovered exiting from the toe of the concrete about 50' from the right end. Flow was estimated as about 1 gpm from this leak.

d. Reservoir Area

There is no development around the shores of Tower Hill Pond, as recreation is prohibited. The area is well patrolled by the Water Works, although occasional trespassers are evident.

e. Downstream Channel

The stone masonry channel from the main dam leads to the natural stream bed of Maple Falls brook. The channel is slightly overgrown with shrubbery.

The spillway discharges into a small stream bed which joins with Maple Falls Brook below the main dam. The channel just past the spillway is somewhat overgrown with trees and shrubs and would restrict passage of flood flows which the spillway would otherwise be capable of passing.

3.2 Evaluation

There is no evidence that either the dam, dike, or spillway is unstable.

The two erosion paths on the main dam and small leak through the spillway could become problems if left unrepaired.

Sediment that is accumulating against the upstream side of the spillway should be routinely removed to prevent growth of flow-restricting vegetation. Likewise, and for the same reason, the downstream channel from the spillway should be kept clear.

The wet area downstream from the main dam, and the riprap slumps on the main dam and on the dike should be monitored. Professional advice should be sought if there are changes in these conditions.

The poor operation of the gates hinders the utility of the overall water supply development, restricting the flexibility of use as intended by the designer.

SECTION 4: OPERATIONAL PROCEDURES

4.1 Procedures

In the fall, usually October, the upper gate is opened and the pond is drained down about 12' below the spillway level. The gate is kept open over the winter. After "ice-out" the gate is closed and the pond is allowed to fill to overflowing the spillway. During the summer, in times when the pool level is below the spillway, the upper gate is opened partially to allow for a nominal flow to pass down to Massabesic Lake.

4.2 Maintenance Of Dam

The dam embankments are maintained free of trees and shrubs. Riprap repairs are performed by dumping new stone. Repairs to the roadway surface, guardrail, and cut stone roadway wall are reportedly planned for the near future. Other routine maintenance is performed regularly.

4.3 Maintenance Of Operating Facilities

The only gate being used at present is the upper of three gates. The gates are in poor repair. Flashboards are no longer employed on the spillway.

4.4 Description Of Any Warning System In Effect

There is no formal warning system, though the dam and reservoir area is regularly patrolled.

4.5 Evaluation

The operating procedure is simple yet adequate.

The maintenance of the dam structure appears adequate, though some areas need attention.

The maintenance of the operating facilities has been somewhat overlooked, repairs to the gates now being necessary as well as a future program of regularly exercising the gates.

SECTION 5: HYDRAULIC/HYDROLOGIC

5.1 Evaluation Of Features

a. Design Data

From the notes and computations available it is obvious that considerable attention was paid to hydraulics and hydrology in the design of Tower Hill Pond Dam. Unfortunately a good bit of the information is fragmented, and there is no single coherent report available indicating hydrologic and hydraulic design criteria. However, the following is known about the design:

- (1) Stage-storage and stage-area curves were developed.
- (2) The possibility of Sawyer Pond Dam failing was considered.
- (3) Flood routing studies were performed to determine the peak runoff for Tower Hill Pond. Using a rainfall of 1" per hour for 6 hours, design computations indicate a peak inflow of 8,600 cfs occurs in 4 hours, and a peak outflow of 7,800 cfs occurs in 6 hours.
- (4) Wave overtopping was not considered.
- (5) A 150' spillway of 5.3 feet freeboard was selected. (As Built: 250' with 5.0' freeboard)

b. Experience Data

No data on the dam's hydraulic performance was uncovered, and it is believed that no records have been kept. The following is fairly certain however:

- (1) The dam has been never overtopped.
- (2) No distress during flooding has ever been reported.

c. Visual Observations

There is no evidence of the dam having been overtopped.

Some aquatic growth has developed on the right end of the spillway approach channel, restricting the flow capacity. The channel downstream from the spillway is overgrown with trees and shrubs, which restricts the flow which the channel could pass. This could cause back-flooding into the reservoir. The poor condition of the gates hinders their capacity to assist in carrying off flood waters, though this is quite small in relation to the spillway capacity.

d. Overtopping Potential

The hydrologic computations performed as part of this report are included in Appendix D.

The Probable Maximum Flood (PMF) for Tower Hill Pond Dam is computed to be about 8,750 cfs inflow into the pond. The PMF is defined as the largest flood that can be reasonably expected to occur on a given stream at a selected point, or the flood that may be expected from the most severe combination of critical meteorologic & hydrologic conditions that are reasonably possible in the region.

For dams of the size and hazard classifications of Tower Hill Pond dam, the test flood is generally selected between one-half of the PMF and the full PMF. The test flood is that flood used to evaluate the hydraulic adequacy of a project. Considering the endangerment to the Massabesic Lake Dam, a high hazard structure downstream, and the likelihood of future development in the area, it is prudent to select the full PMF as the test flood.

At a pond elevation equal to the top of the dam, the spillway capacity is about 10,300 cfs. The peak outflow at the dam during test flood conditions is about 8,080 cfs, the reduction from the peak inflow of 8,750 cfs

being accounted for by the surcharge storage "cushioning" effect of the reservoir. At the moment of peak outflow, the spillway would pass the full test flood with about 0.8 feet of freeboard to spare.

It should be mentioned that during an 80 mph wind (a likely occurrence during a hurricane) wave height would be about 2.5 feet. Considerable damage to earth dams can occur due to wave overtopping. If this wave action is not ignored, spillway capacity drops to about one-half the PMF. If the dam crest were raised about one foot and a good wave protection wall was erected 1' high above the new crest, the present spillway could pass the PMF without being overtopped by waves.

SECTION 6: STRUCTURAL STABILITY

6.1 Evaluation Of Structural Stability

a. Visual Observations

The main dam is an earthen embankment. There is a rock drain at the downstream toe, and one concrete pipe, which apparently carries discharge from a gravel underdrain beneath the downstream slope. The upstream slope of the dam is covered with riprap which is in generally good condition. No trees or brush are growing on the upstream slope. In a few locations, it appears that the riprap has settled a few inches immediately adjacent to the crest, but there is no sign of bulging lower down on the slope, or settlement of the crest itself, or deformation of the downstream slope. The downstream slope of the main dam is covered with grass and is in generally good condition. There are two motorcycle paths from the crest to the toe of the dam on the downstream slope and signs of trespassing and lack of vegetation at the contact between the downstream slope and both abutments. There is also what appears to be a small bulldozer cut at the downstream toe near the center of the valley. The area downstream of the toe was covered with trees and brush, and there was one wet area in this vicinity.

Except for the small seepage noted in Section 3, the spillway appears in good structural condition.

The dike is an earthen embankment with a rock drain at the downstream toe. The upstream slope of the dike is covered with riprap which is in generally good condition. No trees or brush are growing on the upstream slope. The downstream slope is covered with grass and is in generally good condition. There are two minor topographic irregularities on the downstream slope. They do not appear to be associated with any stability problem. The area downstream of the dike is covered with trees and brush. No evidence of seepage was observed in this area.

b. Design And Construction Data

The design appears to have been competently handled, although there are no boring logs or soils analyses.

No construction data exists which would bear on a structural stability evaluation.

c. Operating Records

No operating records have been kept.

d. Post Construction Changes

No significant post construction changes have been implemented.

e. Seismic Stability

The dam is located in a Seismic Zone 2 and hence does not have to be evaluated for seismic stability according to the OCE Recommended Guidelines.

SECTION 7: ASSESSMENT, RECOMMENDATIONS, AND REMEDIAL MEASURES

7.1 Dam Assessment

a. Condition

Examination of available documents and visual inspection of the Tower Hill Pond dam did not reveal any conditions which would render the project inadequate. The main dam, dike and spillway are assessed to be in overall good condition.

Spillway capacity is quite good, even if the secondary action of overtopping by waves is considered. The embankment slopes have been kept clear of trees and brush, an important feature since roots can become paths for leakage if allowed to grow.

Some recommendations and remedial measures are outlined below.

b. Adequacy Of Information

The design information is good but its usefulness is limited by the absence of construction and operation information. Primarily the evaluation contained in this report is based on the following:

- (1) The design plans, specifications, and computations.
- (2) The apparent absence of serious problems throughout the dam's life time.
- (3) The visual inspection.

Information which is missing is:

- (1) As-built drawings.
- (2) Construction inspection reports, photographs and test results.

- (3) Soils and geologic information.
- (4) Operation records and pond levels.

c. Urgency

The recommendations and remedial measures below should be carried out by the owner within two years after receipt of this Phase I Report, except for the monitoring programs which should begin as soon as can be arranged.

d. Necessity for Additional Information

There is no need for additional inspection on Tower Hill Pond Dam at this time, except for those monitoring programs mentioned below.

This dam should undergo a thorough inspection by a competent engineer once every two years, in addition to regular observation visits by maintenance personnel.

7.2 Recommendations

- a. Repair or replace the three gates to restore them to fully operational status. Also replace the floor of the gate house with one designed to resist the thrust caused by the gate operating mechanism.
- b. Investigate the small leak at the spillway and make repairs.

7.3 Remedial Measures

- a. Alternatives: N/A
- b. Operating and Maintenance and Procedures
 - (1) Establish a program of monitoring the extent of riprap settlement and the wet area at the downstream toe of the dam. Such programs would best involve recorded measurements from set bench marks as well as photographs. The program should be continued until it is certain that the situations are stable or not. If

not stable, a competent engineer should be retained to investigate and make recommendations.

- (2) Begin keeping regular level records on the pond, and record all changes in positioning gates and similar operations data. A permanent log should be kept.
- (3) Augment the existing program of regular visits by keeping a permanent log of general observations.
- (4) Exercise all gates and other moving parts regularly, once needed repairs are accomplished.
- (5) Round the clock surveillance should be provided by the owner during periods of unusually high flows caused by heavy precipitation, rapid snowmelt, or other reasons. The owner should develop a formal warning system with local officials for alerting downstream residents in case of emergency.
- (6) Clear the area upstream of the spillway of aquatic growth.
- (7) Clear the area downstream from the spillway of trees and shrubs.
- (8) Repair the erosion paths on the downstream face of the main dam.
- (9) Repair the cut stone walls along the upstream edge of the roadway and repair the wood guardrail.
- (10) Re-establish grass growth in bare areas.

TOWER HILL POND DAM

APPENDICES

<u>Appendix</u>	<u>Description</u>
A	Visual Inspection Checklist - 10 pp.
B	Engineering Data with Index
C	Inspection Photographs with Index - 12 photos
D	Hydrologic Computation
E	Information as Contained in the National Inventory of Dams

APPENDIX A
VISUAL INSPECTION CHECK LIST
PARTY ORGANIZATION

PROJECT Tower Hill Pond Dam DATE June 12, 1978*

Auburn, New Hampshire TIME 1:00

WEATHER Sunny, hot

W.S. ELEV. 321.2 U.S. DN.S.
(1" over spillway
crest)

PARTY:

1. <u>T. T. Chiang, W & H</u>	6. _____
2. <u>J. Scott, W & H</u>	7. _____
3. _____	8. _____
4. _____	9. _____
5. _____	10. _____

PROJECT FEATURE	INSPECTED BY	REMARKS
1. <u>Everything but gates</u>	<u>Chiang & Scott</u>	
2. <u>Gates</u>	<u>Scott (on 3/13 with</u>	
3. _____	<u>E. Howard,</u>	
4. _____	<u>Maint. Foreman)</u>	
5. _____		
6. _____		
7. _____		
8. _____		
9. _____		
10. _____		

*Additional inspection performed - see next sheet

Check list combines comments of both visits

VISUAL INSPECTION CHECK LIST
PARTY ORGANIZATION

PROJECT Tower Hill Pond Dam
Auburn, New Hampshire

DATE July 5, 1978

TIME 2:00

WEATHER Clear, warm

W.S. ELEV. 320.8 U.S. DN.S.
(Just below spillway
crest)

PARTY:

1. J. Scott, W & H
2. R. Hirschfield, GEI
3. _____
4. _____
5. _____

6. _____
7. _____
8. _____
9. _____
10. _____

PROJECT FEATURE	INSPECTED BY	REMARKS
1. <u>All</u>	<u>Scott & Hirschfield</u>	
2. _____		
3. _____		
4. _____		
5. _____		
6. _____		
7. _____		
8. _____		
9. _____		
10. _____		

*Previous inspection performed - see previous sheet

Check list combines comments of both visits

PERIODIC INSPECTION CHECK LIST

PROJECT Tower Hill DATE 6/12/78 and 7/5/78
 PROJECT FEATURE Main Dam NAME Entire Party
 DISCIPLINE _____ NAME _____

AREA EVALUATED	CONDITION
<u>DAM EMBANKMENT</u>	
Crest Elevation	ok
Current Pool Elevation	321.2(6/12) and 320.8(7/5)
Maximum Impoundment to Date	Unknown
Surface Cracks	None observed
Pavement Condition	Roadway pavement poor
Movement or Settlement of Crest	None observed
Lateral Movement	None observed
Vertical Alignment	ok
Horizontal Alignment	ok
Condition at Abutment and at Concrete Structures	ok
Indication of Movement of Structural Items on Slopes	Catwalk to gate house is misaligned vertically at midspan support - caused by poor bearing design, not dam settlement
Trespassing on Slopes	Two motorcycle paths up d.s. face - general trespassing around abutments
Sloughing or Erosion of Slopes or Abutments	Irregularities at toe - appears stable
Rock Slope Protection-Riprap Failures	Some minor areas of riprap settlement - no bulges below or other distress
Unusual Movement or Cracking at or near Toes	Bulldozer cut at d.s. toe - minor
Unusual Embankment or Downstream Seepage	One wet area 50' d.s. of toe
Piping or Boils	None observed
Foundation Drainage Features	Drain collector system near left abut.
Toe Drains	Rock toe drain along d.s. toe
Instrumentation System	None

PERIODIC INSPECTION CHECK LIST

PROJECT Tower dill DATE 6/12/78 & 7/5/78PROJECT FEATURE Dike NAME Entire Party

DISCIPLINE _____ NAME _____

AREA EVALUATED	CONDITION
<u>DIKE EMBANKMENT</u>	
Crest Elevation	ok
Current Pool Elevation	321.1(6/12) and 320.8(7/5)
Maximum Impoundment to Date	Unknown
Surface Cracks	None observed
Pavement Condition	Roadway poor
Movement or Settlement of Crest	Some minor irregularities associated with poor roadway
Lateral Movement	None observed
Vertical Alignment	ok
Horizontal Alignment	ok
Condition at Abutment and at Concrete Structures	ok
Indications of Movement of Structural Items on Slopes	No structural items on slope
Trespassing on Slopes	Not much
Sloughing or Erosion of Slopes or Abutments	None observed
Rock Slope Protection-Riprap Failures	Riprap appears small, a few minor settlements
Unusual Movement or Cracking at or near Toes	Irregularities at toe - appears stable
Unusual Embankment or Downstream Seepage	None observed
Piping or Boils	None observed
Foundation Drainage Features	Stone lined ditch downstream from deepest point - collector for drains?
Toe Drains	Rock toe drain along d.s. toe
Instrumentation System	None

PERIODIC INSPECTION CHECK LIST

PROJECT Tower Hill

DATE 6/13/78

PROJECT FEATURE Intake Structure

NAME Scott

DISCIPLINE

NAME

AREA EVALUATED	CONDITION
<u>OUTLET WORKS-INTAKE CHANNEL AND INTAKE STRUCTURE</u>	
a. Approach Channel	
Slope Conditions	No approach channel - intake structure in central portion of dam
Bottom Conditions	
Rock Slides or Falls	
Log Boom	
Debris	
Condition of Concrete Lining	
Drains or Weep Holes	
b. Intake Structure	Structure appears sound. Wood Frame superstructure in good shape. Walkway has vertical misalignment (poor bearing design - not from settlement), and one plank missing.
Condition of Concrete	
Stop Logs and Slots	
	Gates in poor operating condition: Upper gate works but leaks and sticks Middle gate works and seals ok, but is sticky Operator declined to touch lower gate.
	Floor is weak - cannot take thrust of gate mechanism without excessive deformation. When gate sticks, the cranking motion moves the floorboards.

PERIODIC INSPECTION CHECK LIST

PROJECT Tower HillDATE 6/12/78 & 7/5/78

PROJECT FEATURE _____

NAME _____

DISCIPLINE _____

NAME _____

AREA EVALUATED	CONDITION
<u>OUTLET WORKS-CONTROL TOWER</u>	
a. Concrete and Structural	
General Condition	See previous page for gate house condition.
Condition of Joints	
Spalling	
Visible Reinforcing	
Rusting or Staining of Concrete	
Any Seepage or Efflorescence	
Joint Alignment	
Unusual Seepage or Leaks in Gate Chamber	
Cracks	
Rusting or Corrosion of Steel	
b. Mechanical and Electrical	
Air Vents	No electricity. Only mechanism is gate operators.
Float Wells	
Crane Hoist	
Elevator	
Hydraulic System	
Service Gates	
Lightining Protection System	
Emergency Power System	
Wiring and Lighting System in Gate Chamber	

PERIODIC INSPECTION CHECK LIST

PROJECT Tower Hill DATE 6/12/78 & 7/5/78

PROJECT FEATURE _____ NAME _____

DISCIPLINE _____ NAME _____

<u>AREA EVALUATED</u>	<u>CONDITION</u>
<u>OUTLET WORKS-TRANSITION AND CONDUIT</u>	
General Condition of Concrete	30" discharge conduit through base of dam.
Rust or Staining on Concrete	Outlet end - top of pipe broken, otherwise o.k. Rest of pipe not inspectable.
Spalling	
Erosion or Cavitation	
Cracking	
Alignment of Monoliths	
Alignment of Joints	
Numbering of Monoliths	

PERIODIC INSPECTION CHECK LIST

PROJECT Tower Hill DATE 6/12/78 & 7/5/78

PROJECT FEATURE _____ NAME _____

DISCIPLINE _____ NAME _____

AREA EVALUATED	CONDITION
<u>OUTLET WORKS-OUTLET STRUCTURE AND OUTLET CHANNEL</u>	
General Condition of Concrete	Stone masonry walls in good shape - nicely built.
Rust or Staining	
Spalling	
Erosion or Cavitation	
Visible Reinforcing	
Any Seepage or Efflorescence	
Condition at Joints	
Drain Holes	Flow from toe drain collector pipe extremely reddish - probably high iron.
Channel	
Loose Rock or Trees Overhanging Channel	Trees overhanging channel.
Condition of Discharge Channel	Bottom covered w/ boulders. Some grass & brush beginning to grow in channel a short distance downstream.

PERIODIC INSPECTION CHECK LIST

PROJECT Tower Hill DATE 6/12/78 & 7/5/78
 PROJECT FEATURE Spillway NAME Entire Party
 DISCIPLINE NAME

AREA EVALUATED	CONDITION
<u>OUTLET WORKS-SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS</u>	
a. Approach Channel	Not really a channel.
General Condition	Good
Loose Rock Overhanging Channel	None
Trees Overhanging Channel	None
Floor of Approach Channel	Sand & gravel accumulated against spillway - aquatic grass at right end.
b. Weir and Training Walls	Good. Slight amount of uniform erosion on flowed surfaces. Degree of erosion easy to gage and not severe.
General Condition of Concrete	None
Rust or Staining	None - Surface good
Spalling	None
Any Visible Reinforcing	Trickling leak under toe of spillway at second pier from right end - about 1 gpm. Some constr. joints damp.
Any Seepage or Efflorescence	None
Drain Holes	Poor. Doesn't look like it could pass a flow equal to spillway capacity
c. Discharge Channel	
General Condition	None
Loose Rock Overhanging Channel	Trees growing across entire width of channel
Trees Overhanging Channel	Bedrock, boulders, thin soil cover
Floor of Channel	trees & brush
Other Obstructions	

PERIODIC INSPECTION CHECK LIST

PROJECT Tower Hill DATE 6/12/78 & 7/5/78
 PROJECT FEATURE Catwalk to Gate House NAME Scott
 DISCIPLINE _____ NAME _____

AREA EVALUATED	CONDITION
<u>OUTLET WORKS-SERVICE BRIDGE</u>	
a. Super Structure	
Bearings	Poor design of bearing at midspan support - has caused vertical misalignment.
Anchor Bolts	ok
Bridge Seat	See "bearings"
Longitudinal Members	Steel beams ok
Under Side of Deck	Simple planking - ok
Secondary Bracing	Some needed
Deck	One plank missing
Drainage System	None
Railings	Good
Expansion Joints	Roller support - may not work evenly because of midspan bearing. Will not, however, fail to move.
Paint	ok
b. Abutment & Piers	
General Condition of Concrete	Good
Alignment of Abutment	Good
Approach to Bridge	None as such
Condition of Seat & Backwall	

APPENDIX B
ENGINEERING DATA

Plate - Plan & Section, Main Dam

Plate - Dike & Spillway

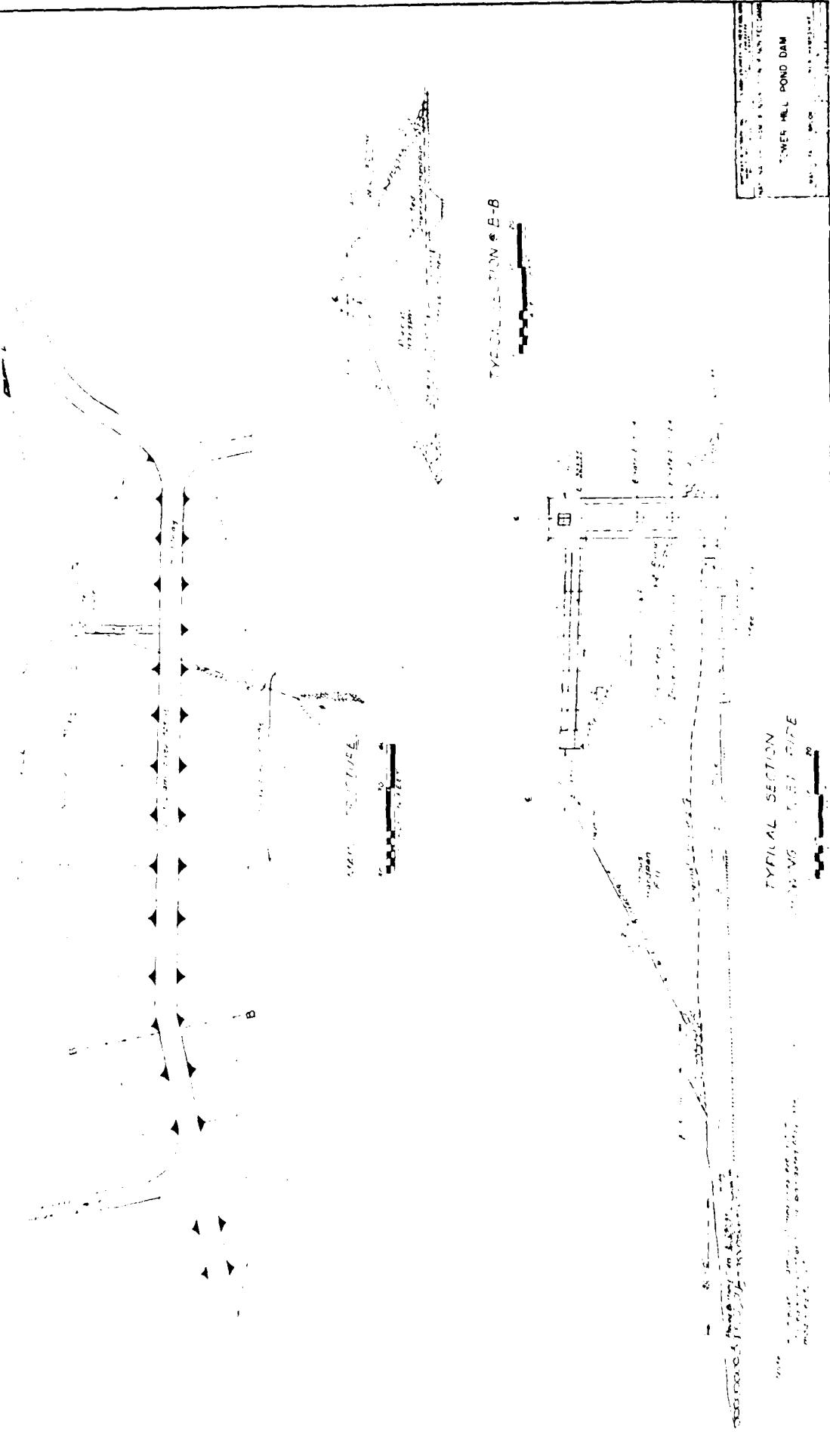
N.H. Water Resources Board, Dam Safety Inspection
Report Form, 11/9/73

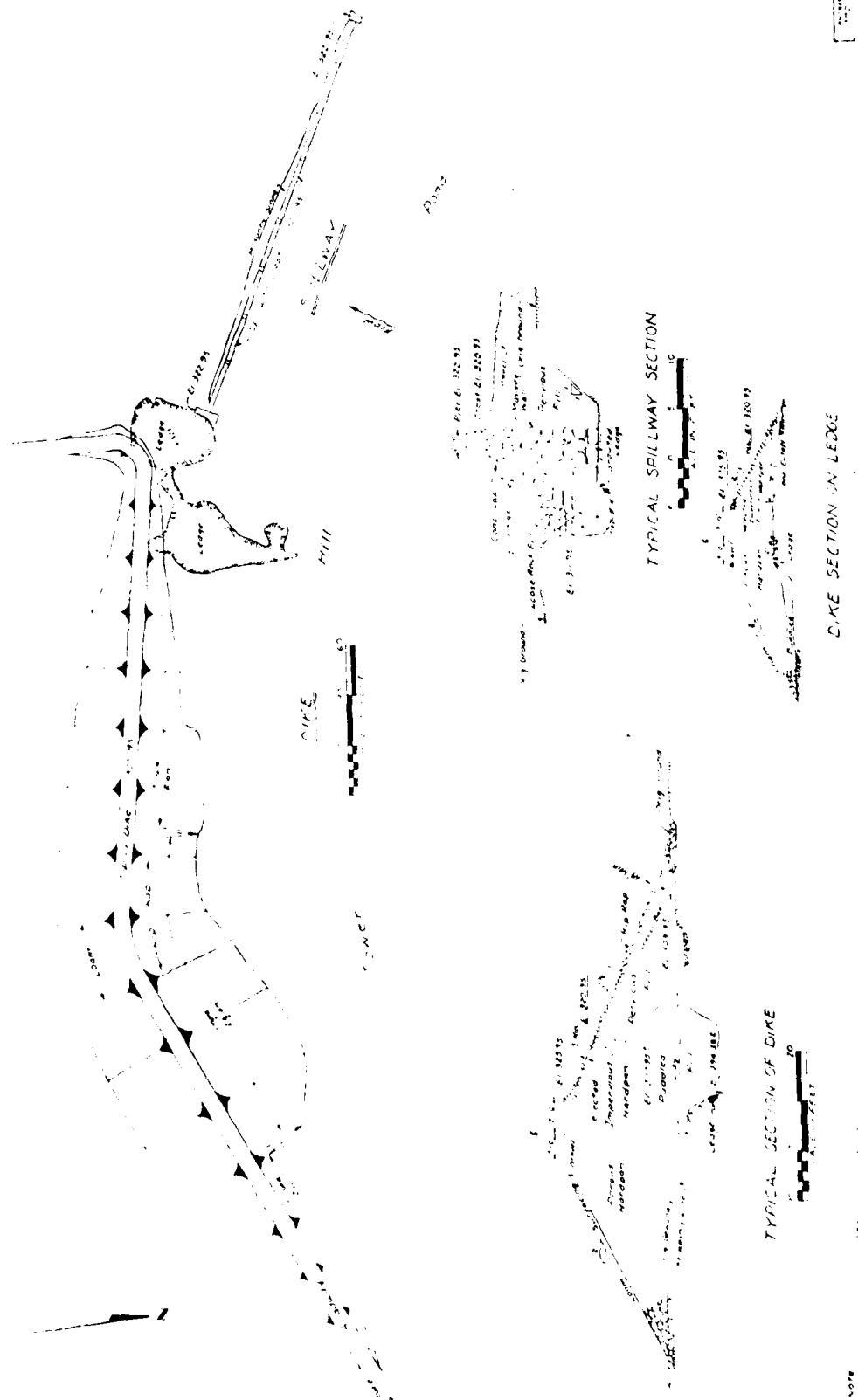
Runoff-Storage Table, 1/45

Specifications for dike & spillway, 2/8/39. 6 pages

Summary of design hydrology & spillway computations,
12/22/38 by C.E.F.

Specifications for main dam, 7/6/38, 8 pages





TYLER HILL POND CAM

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N. H. WATER RESOURCES BOARD
Concord, N. H. 03301

DAM SAFETY INSPECTION REPORT FORM

Town: Acc. 21 Dam Number: 311

Inspected by: Paul Date: 11-9 1973

Local name of dam or water body: Ta. - 1516

Owner: City of Concord Address: _____

Owner was/was not interviewed during inspection.

Drainage Area: 125 sq. mi. Stream: _____

Pond Area: ~ 150 Acre, Storage 1655 Ac-Ft. Max. Head ft.

Foundation: Type Earth, Seepage present at toe - Yes No

Spillway: Type Earth w/2.0 2.0, Freeboard over perm. crest: 5 3',

Width _____, Flashboard height 2,

Max. Capacity _____ c.f.s.

Embankment: Type Earth - 1/2-1/3, Cover 5 ft. Width 12' / ft.

Upstream slope _____ to 1; Downstream slope _____ to 1

Abutments: Type _____, Condition: Good, Fair, Poor

Gates or Pond Drain: Size 24" Capacity _____ Type P. P.

Lifting apparatus _____ Operational condition _____

Changes since construction or last inspection:

Downstream development:

This dam would would not be a menace if it failed. Re no or or or or

Suggested reinspection date: _____

Remarks: None

Manchester Water Works
ENGINEERING DEPT
MANCHESTER, N.H.

Mass. Lake - Tower Hill Pond

Comparison of Storage

Page 1

Date Jan 1945

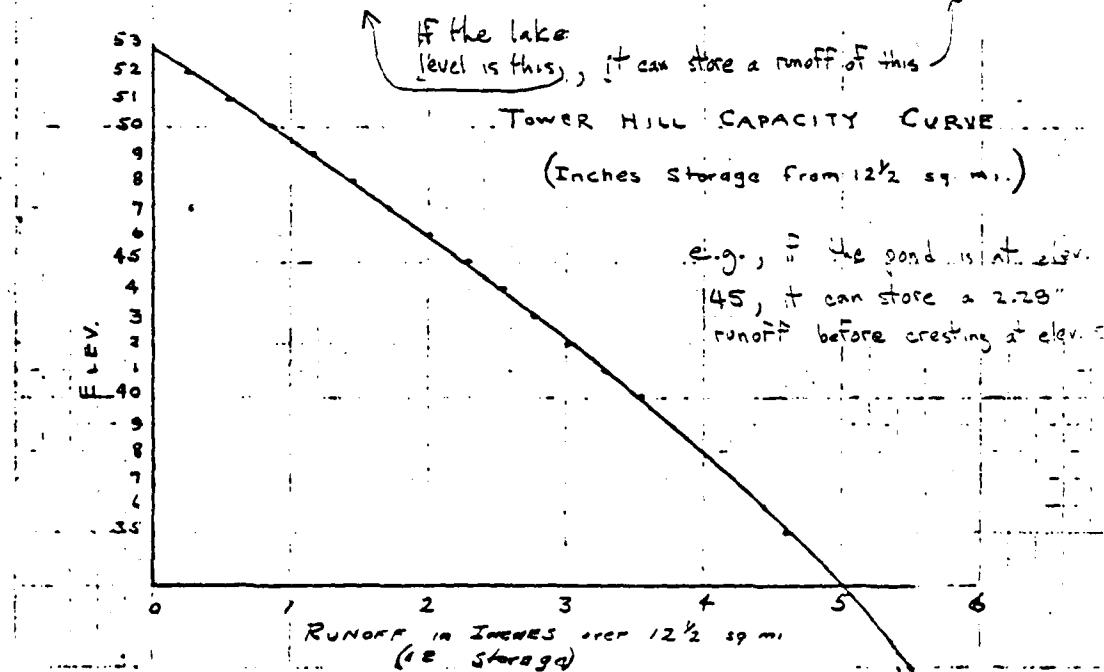
Prepared by C.E.F.

TOWER HILL WATERSHED

Drainage Area = 12 1/2 sq. mi.

Top of Flashboards = Elev. 53.0
Concrete Spillway = " 52.0

Elev.	Pond capacity m.g.	Total Storage	Storage m.g./sq mi.	Runoff on 12 1/2 sq. mi. inches
53.0	1350	73		
52.0	1300	50	4	.23
51.0	1230	120	9.6	.55
50.0	1165	185	14.8	.85
49.0	1100	250	20.0	1.15
48	1035	315	25.2	1.45
47	980	370	29.6	1.7
46	915	435	34.8	2.0
45	855	495	39.6	2.28
44	800	550	44	2.54
43	750	600	48	2.76
42	700	650	52	2.99
41	640	710	56.8	3.27
40	580	770	61.6	3.55
35	350	1000	80	4.60
30	155	1195	95.4	5.49
23.5	0	1350	100.8	6.23



TOWER HILL DAM SPECIFICATIONS
DYKE AND SPILLWAYSTRIPPING

Strip entire area to be covered, by earth dykes, of all top soil, stumps, large roots, loose and nested boulders; and the area covered by concrete spillway of all earth above original ledge. (Refer to plans and concrete specifications) Boulders and cobbles go to riprap on the upstream slope. Roots and stumps should be placed in piles for future burning. Top soil should be stored for future use in landscaping site.

EXCAVATION

Excavate for the cutoff trench as shown on the plans. The depth and widths shown are minimum and if they do not place the bottom of trench into firm, uniform material, the cutoff shall be continued in depth satisfactory of the Chief Engineer. Where ledge is encountered 4' or less from original ground surface between Elevations 34.0 - 42.0 the cutoff base shall be widened to a width of 8', and for ground surface above Elevation 42.0 a base width of 5' will be sufficient. Where depth of ledge is greater than 4' soundings must be made to determine if ledge is less than 5' from original ground surface. If this case is found, cutoff must be extended to ledge and to the widths specified above. All stone from this excavation over 5" in diameter shall be placed in either the downstream toe or upstream riprap. The remainder of the material shall

be placed in the more pervious part of the fill according to the specification regarding embankment fill.

DYKE AND SPILLWAY

CUTOFF AND EMBANKMENTS

Where the cutoff trench is in firm uniform material it shall be filled with the impervious hardpan which has been selected for the impervious fill. This fill shall be placed with all stones 5" or greater removed, and tamped or rolled to obtain maximum density. Where the base of the cutoff is on ledge, the ledge must be thoroughly cleaned and covered with a minimum thickness of 12" of a puddled selected clayey material. The remainder of the cutoff trench shall be filled with the selected impervious material compacted as above.

The impervious part of the embankment shall be placed in layers which before rolling shall not exceed 8" in thickness. All stones 5" or over shall be removed before rolling. Roll the fill with tractor drawn sheepfoot roller until it is firm and hard below the loose top stirred up by the equipment. Probably at least 12 passes of the equipment over each area will be required for sufficient compaction. If the material is not moist enough for sufficient compaction, it shall be sprinkled with water until it has the necessary moisture. The material used for the impervious part of the fill shall be obtained from the selected hardpan pit that was used for the earth dam construction.

The downstream part of the dyke shall be of more

pervious fill which will be obtained from borrow pits west of the site. The method of placing and compacting as used in the impervious material shall be followed. The moisture content is to be increased by sprinkling if it is found to be deficient for best compaction during placement.

Where the two types of fill come together they should be rolled in thin, lapping layers to obtain a good bond. If the surface of the old embankment becomes hard it shall be loosened before fill is placed on it. Earth embankment shall not be placed on frozen ground and neither shall frozen earth be placed in the fill.

RIPRAP AND TOE FILL

Stones from the embankment material will be placed either in the stone toe fill or on the upper face of the embankment. Between the upstream riprap and the impervious fill shall be placed a layer of 6" of gravel. Use all the stone from the fill even though the riprap is thicker than specified. If there is not enough stone from the fill, additional stone must be secured to meet requirements of riprap thickness. Keep the stone riprap below the top of the fill so that the face of the fill may be formed by rolling. When the fill is complete the face of the riprap should be evened by hand spreading of the stone, but a smooth paving is not intended.

CONCRETE

Concrete shall consist of Portland cement, sand and screened gravel.

Cement shall meet the requirements of the current "Standard Specifications and tests for Portland Cement" adopted

by the American Society for Testing Materials. It shall be stored in a dry house well above the ground.

Sand shall be clean and at least 90% silica.

Before preparation for use it shall be tested for vegetable matter by the "Colorimetric Test" described in the "Standard Method of Test for Organic Impurities" of the American Society for Testing Materials. If the color is darker than "Straw" color the bank shall not be used.

Gravel shall have the sand screened out. It shall be hard durable and clean and must not contain iron bearing or "rusty" stones which will discolor the work.

Concrete for the wingwalls and spillway shall be composed of one part cement to six parts of separate volumes of fine and coarse aggregates. Total water per bag of cement shall not exceed seven gallons.

Concrete shall be mixed in a batch mixer. It shall be mixed for at least 2 minutes after all materials are in the mixer. Partly set concrete must not be used.

Take care that concrete is not dropped into the forms so as to segregate materials. Work the concrete thoroughly into place and spade all faces to secure a dense surface. So far as possible deposit the concrete where it is to stay in the forms.

PREPARATION OF LEDGE

The spillway sections are to be placed on ledge and to line and grade as specified on plans. Where the concrete is to be placed on smooth ledge it is necessary that special

precautions be taken to get a maximum bond between concrete and ledge. Either tooling the ledge or an acid preparation for cleaning ledge may need to be used to thoroughly clean the ledge. This is a very important item and the procedure must be satisfactory to the Chief Engineer. Finish each section between construction joints before pouring is stopped for the day. All concrete must be thoroughly cured to obtain maximum strength.

FORMS

Forms are to be faced with planed matched boards. Framing must be heavy enough and sufficiently braced to keep the lines true. The top or cap form for the rounded corners of the spillway shall be constructed according to design approved by the Chief Engineer. These should be designed so that they can be used throughout the whole job.

REINFORCING STEEL

Use round deformed bars purchased locally. Place 1/2" round steel as shown on plans.

LOAM SURFACING

Loam is to be placed on the downstream slope to a depth of approximately 6". This should be raked to line and grade, sowed with grass seed and rolled.

FLASHBOARDS

Both the pins and flashboards shall be of durable construction as they are not expected to be replaced very often. The flashboard pins shall be made of galvanized iron pipe and the flashboards of 2" tongue and grooved stock, painted with two coats of creosote.

The size and spacing of pins for the flashboards will be determined by actual test for strength.

S.
12/22/58
C.E.F.

TOWER HILL DAM
SUMMARY OF SPILLWAY CAPACITY
REQUIRED. (100% of 3 sec.)
IN QUARTERS. (400 sec.)

A. DATA:

I. TOWER HILL DAM IN AUGUSTA AND CARIBOU, I. H.

- a. CONST. OF EARTH DAM TO RAISE Pond 25'.
- b. WORK DONE by W.P.A. but sponsored and
SUPERVISED by MANCHESTER WATER WORKS.
- c. Storage (Total Capacity) 1,200,000 cu. ft. (1/4 sec.)

II. WATERSHED AREA: 12.5 sq. mi. = 80 acres.

- a. Light to Heavy Woods, also swamps see page 2
- b. MAX. RAINFALL USED = 1" per Hour for 6 hours duration.
- c. No SNOW Considered as -
- d. Runoff Factor = 100%?
- e. Slope (Land) varies from 1% - 2.3% VEL. USE: 1/2 min. - 1/4 min.
- f. Slope (Brook) " " APP. 1% VEL. " 2 mph - 4 mph.

B. FACTS SUBSTANTIATING ABOVE ASSUMPTIONS

- a. MAY EXPECT ONCE in 100 yrs. 1.1" / hr. for 4 hrs } USDA
" " " " " .63" / hr. for 8 hrs } REPORT
So over 1" / hr. rainfall is in 3 sec. 5 min.
- b. 1927 Flood in JT. 9.6 sec. 5 min.
" " " Return 9.0 sec. 4 min.
- c. Runoff FACTOR: C.
1936 Flood 9" runoff in 15 days - RA. = 17" ± 1. Assume 50%
runoff on this basis. Unlike other New England Rivers E
Manchester.
- d. BARRING PT. PPT. 700" = 50% = 350" = 1/2 min. = 30 sec.
- e. OBS. R. Runoff over 1936 Flood at T.H. Pond = 60% C
- *f. We could conceive of a MAX. RAIN, with Warm Weather on
a Frozen Lake - OR - EITHER IN LATE FALL OR LATE
WINTER in the 100% assumption
- g. Velocities - Small streams - Lateral Surges $\frac{1}{2}$ - 1 mph.
" " " Small brooks 2 - 4 mph.
CSEE - C. 1/2 min. Brook 2 mph.
- h. MAX. Runoff Q = 300 sec. cu. ft. in C = 5
U.S.D.A. REPORT. = For C = 1.0 = 750 sec. cu. ft.

Peak Flood = 14 sec. = 400 cu. ft. per sec.

- *f. The Morning of a Southern Storm with a Local
Storm - 40 sec. has saturated the water table.

TOWER HILL DAM
SUMMARY OF SPILLWAY CAPACITY
REQD. (PAGES 1-13 inc.)

S₂
12/22/38.
CEC

C. SOLUTION

I. WATERSHED FOR POND DIVIDED INTO 5 SUB AREAS -

- POND Area & adjacent Slopes.
- MOOSE MEADOW Area.
- Wooded Section N. of Moose Meadow Area.
- SOURCE POND Area.
- Clay Area.

SEE KEY MAP

II Period of Concentration for Sub Area is 0.2

III TOTAL CONCENTRATION PERIOD TO POND p. 3.

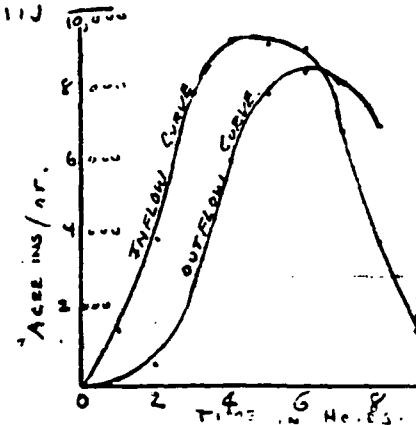
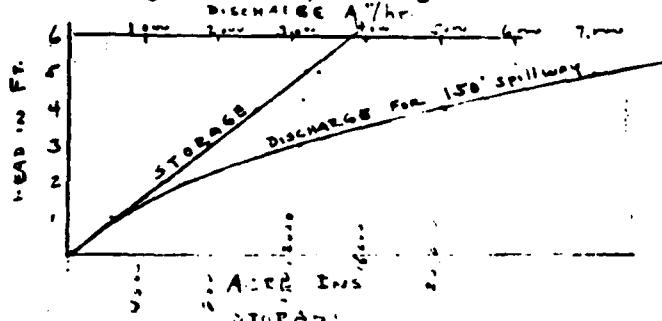
IV Treatment of EACH AREA Separately (p. 4, 5, 6, 7) to obtain
INFLOW CURVES on BOTTOM of PAGE 8

V COMBINATION OF SUB-CURVES to OBTAIN

TOTAL INFLOW RATING CURVE
SEE PAGE 8

VI STORAGE & DISCHARGE Curves Drawn

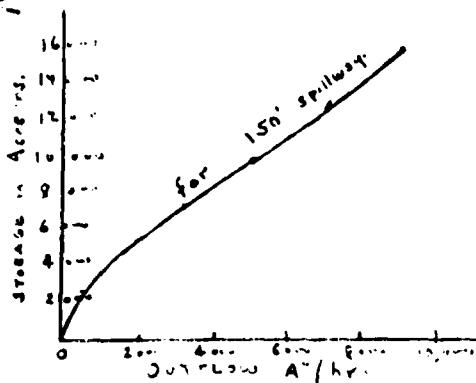
UP SEPARATELY AS.



VII. The Above Curves Combined to form
STORAGE OUTFLOW CURVE to check
CALCULATIONS AS.

for

VIII OUTFLOW COMPUTATION SHEET (p. 12)
with Curve on p. 8. Superimposed on
Inflow Curve. As. Above Curve.



TOWER HILL DAM.
 SUMMARY OF SPILLWAY CAPACITY
 REQ'D. (PAGES 1-13 inc)

S 3.
 12/22/38
 CEF.

D. CONCLUSIONS.—

I THE 1"/hr. for 6 hrs as assumed will give a maximum inflow of approx. 760 c.f.s./sq.m. Considering failure in Sawyer Pond Dam—
 a. Without failure of Dam we get 640 c.f.s./sq.m. runoff.

II. It takes 4 hours to reach max. runoff or inflow and it continues until the rain stops, when a sharp decline is noticed.

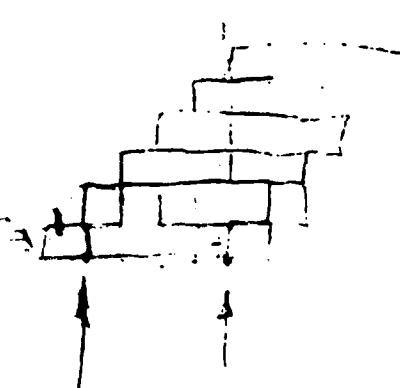
NOTE:— I believe the Drop off side of the runoff curve is only Theoretical. It would seem that the swampy parts of the watershed would cause retardation, more than is shown here. This means that perhaps the "dumping" discharge of the sub-areas was assumed too large.

AT ANY RATE I BELIEVE THAT THE INFLOW CURVE IS DESIGNED FOR THE MAXIMUM WITH THE PRESENT DATA AVAILABLE.

III. THE MAX. DISCHARGE NEEDED is App. 7800 A"/hr. = 7800 c.f.s.
 FOR a 150' Spillway assuming Max. Q Thru 30" discharge line when Pond reaches 54' EL.

Max. Est Thru 30" R = 150 c.f.s.
 Necessary for Spillway $\frac{7600 \text{ c.f.s.}}{150} = 51.3' = 51 + 5.3 = 56.3' = 5.84' \text{ or } 56.3' \text{ EL.}$

IV THE 57.5 Acre inch/hr. flood was reduced 10% by virtue of the storage above the flow line.



Jan 13, 19

TOVER HILL DAM
CONSTRUCTION PROGRAM AND
SPECIFICATIONS
FOR
CONSTRUCTION

TOVER HILL DAM

CONSTRUCTION PROGRAM

1. Strip site - piling soil for later application to down stream face of dam.

Place surface stone in down stream embankment toe and storage piles.

Strip entire site for high dam to elevation 45.0

2. Trench for outlet pipe - Excavate to middle of present road fill - lay pipe to center - backfill and excavate to tower base.

3. Start tower base excavation as soon as pond is drawn low enough. Use excavated material as cofferdam.

4. Strip area for upstream portion of fill which is to form cofferdam. Fill this cofferdam from the west side to the outlet tower and from the east side to the outlet tower. Use material from impervious pit. Use bag coffer at tower where necessary. Keep all boulders over 5 inches out of cofferdam in the center of the valley where the base of the dam is below elevation 28.0

5. Build the outlet tower to elevation 33.0 while excavating cutoff on higher ground.

6. Dig drainage ditches - placing excavated material in pervious fill area.

7. Dig trench at spillway site to elevation 31.0. Keep bags on hand for use on earth coffer to divert water through this trench if necessary.

8. Place impervious fill in cutoff and to the top of the old embankment; then alternate shovel in impervious and pervious pits bringing two types of fill up together and bonding by careful rolling.

3. When the dam is substantially complete to elevation 45.0 build the crib spillway in the west valley.

TOWER HILL DAM

SPECIFICATIONS

STRIPPING

Strip the entire area, not covered by existing embankment, for the high dam below elevation 45.0. (See plan) Remove top soil, stumps and large roots, loose and nested boulders. Boulders and cobbles go to the downstream toe of the dam and to storage piles. Soil and muck are to be piled for later application to the downstream face of the dam. Roots and stumps should be piled for later burning.

EXCAVATION

Excavate for 30" Cast Iron pipe outlet line, which, as shown on the plans, shall be entirely in the original ground. Back fill around pipe with selected hardpan containing no stones over four inches. (Use impervious pit material) Do not allow any cobbles or smaller stone to form packets of stone against the pipe. Carefully and thoroughly hand tamp backfill clear to the top of the trench. Lay Cast Iron pipe to line and grade, using hydrotite or leadite for joints hand caulked, except the first joint near the outlet which shall be a Dresser coupling.

Excavate the drainage ditches in the present fill, as shown, to a minimum width and depth of two feet with the bottom of the cross trenches at an even grade sloping to the downstream toe. Line the trenches with a 6" thickness of sand graded from fine to $\frac{1}{2}"$ and fill the center portions with gravel graded from $\frac{1}{2}"$ to 2". Tamp this fill in place to within 6" of the top of the

trench. Fill the top with 6' of fine to $\frac{1}{2}$ " sand, tamped.

Excavate the cutoff trench as indicated on plans.

The depths shown shall be minimum and if they do not place the bottom of the trench well into firm, uniform material the cutoff shall be continued into material satisfactory to the Chief Engineer.

All stone from these excavations over 5 inches in diameter shall be placed in the downstream toe of the dam; or stored for riprap; the remainder of the material shall be placed in the pervious fill area and shall be tamped, or rolled as specified for the placing of embankment.

CUTOFF AND EMBANKMENT

Fill the cutoff trench and the area indicated on plan and sections with the hardpan selected for impervious fill. This fill shall be placed in layers which before rolling shall not exceed 3 inches in thickness. All stones 5 inches or over shall be removed before rolling. Roll the fill with tractor drawn sheepfoot roller until it is firm and hard below the loose top stirred up by the equipment. At least 3 passes of the equipment over each area will be required for sufficient compaction. If the material is not sufficiently moist to pack well as it comes from the bank it shall be sprinkled with water as deposited so that it will pack; but not enough so that it will become mushy or rut deeply under the truck tires. Test for compaction by determining weight of material in proportion to maximum possible weight.

The area downstream from the impervious embankment shall be filled with the hardpan selected for pervious fill. Methods shall be the same as for the impervious fill. This

material being more gravelly will need to be wetter than the more impervious material. The surface of embankment must always be damp before resuming the placing of fill after any stoppage of the work. Where the two classes of fill come together roll to thin, lapping edges to obtain a solid fill.

The surface of the old embankment shall be loosened by ploughing or picking before fill is placed on it. Earth embankment shall not be placed on frozen ground. No frozen earth shall be placed in the fill.

RIPRAP AND TOE FILL

Stones from the embankment material will be placed either in the downstream toe or on the upper face of the embankment. Use all the stone from the fill even if the riprap is thicker than shown. If there is not enough stone in the fill material to keep the riprap at the thickness specified, additional stone must be hauled into meet requirements as the embankment proceeds. Stone from our various gravel pits should be used first. The riprap shall be bedded on a 6 inch layer of run or pit gravel if 50% or more of the fill will pass a $\frac{1}{4}$ " sieve. Keep the stone riprap below the top of the fill so that the face of the fill may be formed by rolling. When the fill is complete the face of the riprap should be evened by hand spreading of the stone, but a smooth paving is not intended.

STONE WALLS

The retaining walls at the entrance to the outlet tower and at the end of the 30 inch pipe shall be of dry masonry bedded on 6" of run of pit gravel. Seventy five percent of the stone used shall be a cubic foot or more in size, chinked with smaller stone. Stones which can be laid to a firm and solid bed shall

be selected. Dry walls shall have a thickness at the base of at least one half the height and a top width of not less than 18 inches.

CONCRETE

Concrete shall consist of Portland cement, sand and screened gravel.

Cement shall meet the requirements of the current "Standard Specifications and Tests for Portland Cement" adopted by the American Society for Testing Materials. It shall be stored in a dry house well above the ground.

Sand shall be clean and at least 90% silica.

Before preparation for use it shall be tested for vegetable matter by the "Colorimetric Test" described in the "Standard Method of Test for Organic Impurities" of the American Society for Testing Materials. If the color is darker than "straw" color the bank shall not be used.

Gravel shall be well graded and washed. It shall be hard durable and clean and must not contain iron bearing or "rusty" stones which will discolor the work.

Concrete for the outlet tower and cutoffs shall be composed of one part cement to six parts of separate volumes of fine and coarse aggregates. Total water per bag of cement shall not exceed seven gallons.

Concrete shall be mixed in a batch mixer. It shall be mixed for at least 2 minutes after all materials are in the mixer. Partly set concrete must not be used.

Take care that concrete is not dropped into the forms so as to segregate materials. Work the concrete thoroughly into place and spade all faces to secure a dense surface. So far as possible deposit the concrete where it is to stay in the forms.

These walls must be water tight against 30 feet head.

The concrete walls of the outlet tower shall be finished above elevation 32.0 by wetting, rubbing with a carbide brick, and washing off any paste formed.

FORMS

Forms are to be faced with planed tongue and grooved boards. Framing must be heavy enough and sufficiently braced to keep the lines true. The wall form for the tower should be designed to raise and use for the entire tower. Have form design approved by Engineer before building.

Cutoffs shall be built with side forms only, end and bottom will be placed against original ground.

REINFORCING STEEL

Use round deformed bars purchased locally. Place steel in center of wall using 3/4 inch round bars on 6 inch centers horizontally and on one foot centers vertically.

GATES

Are to be installed in accordance with the specifications of the Manufacturers.

Don't think this
was ever built - like a concrete
spillway constructed instead

SPILLWAY-TIMBER CRIB

The area upon which the timber crib spillway is to be built shall be stripped of soil, rocks and stumps to the firm subsoil.

The first cross members or sills shall be set into the subsoil so that the upper surface is above the soil not less than one inch or more than 5 inches. The ground shall be sufficiently leveled to make it possible to set these sills as specified above and with tops parallel; they shall step up by $1\frac{1}{4}$ inch or 16 inch steps as the ground rises to the sides.

Longitudinal and upper cross timbers shall be pinned to the timbers they cross with $3/4$ inch round steel rods as indicated on the drawings. The plank shall be firmly spiked to the framing timbers. On the slope 2 inch plank planed one side shall be used and the cracks between covered with inch boards. On the deck matched plank shall be used.

Flashboard pins shall be computed to let go with the water at varying height above the tops of the boards, which shall be two feet high. Pins shall be of mild steel of a diameter larger than required and shall be turned, for a length of 2 inches just above the bearing point, to the exact size required.

As the crib is built it shall be packed with stone to provide weight and additional stiffness.

The upstream toe of the face plank shall be set in a trench, as shown, not less than 2 feet 8 inches deep below the sub-grade. The toe shall then be backfilled with impervious

hardpan, thoroughly tamped into place.

The hardpan fill of the wings shall be tamped carefully around the timbers of the frame abutments to prevent water following along the back of the wall.

The timbers for the crib may be local hard pine, or other timber, slabbed two sides to a thickness of 8 inches. Plank, boards and dimension timber shall be white pine or other wood which can be spiked without splitting. This structure will probably be abandoned within one year and is not expected to have a life exceeding five years.

APPENDIX C
INSPECTIONS PHOTOGRAPHS
INDEX

<u>Photo No.</u>	<u>Description</u>
1	Upstream slope of main dam looking south from north abutment. Gatehouse and service bridge.
2	Crest of main dam looking north from south abutment. Shows riprap face, poor pavement, wood guardrail with some rails missing, & grass cover of downstream face.
3	Drain collector at toe of main dam near north abutment.
4	Erosion along motorcycle path on downstream face of main dam. Other, smaller path in upper right of photo.
5	Looking northwest toward headwall at downstream end of 30-inch diameter low-level outlet pipe which is broken. Above and to the right of the 30-inch pipe is a concrete pipe which carries the drainage from the drain system in the downstream toe near the north abutment.
6	Looking north toward irregular topography at toe of downstream slope of main dam south of deepest part of valley. Appears to be a bulldozer cut and not the result of slumping or other natural causes.
7	Crest of dike, looking west from east abutment, showing cut rock wall along north edge of crest and pavement in poor condition on crest.
8	Upstream riprap on dike. Note unevenness in some areas size of riprap on small side, and some cut stone wall pieces dislodged.

<u>Photo No.</u>	<u>Description</u>
9	Looking north along channel that conveys water from rock drain at downstream toe of dike. Rock drain visible at far end of channel. Downstream slope of dike is the very light area in the background beyond the trees. Iron oxide on bottom of channel is responsible for the orange-brown color.
10	Spillway at west end of dike, looking west from east end of spillway. West abutment in background.
11	From west end of spillway looking east, showing vegetation growing upstream of spillway where sand has accumulated against the spillway.
12	Leak of about 1 gpm at base of concrete spillway (just beneath metal clipboard) near west end of spillway - second pier from end.



2



4



1



3



6



8



5



7



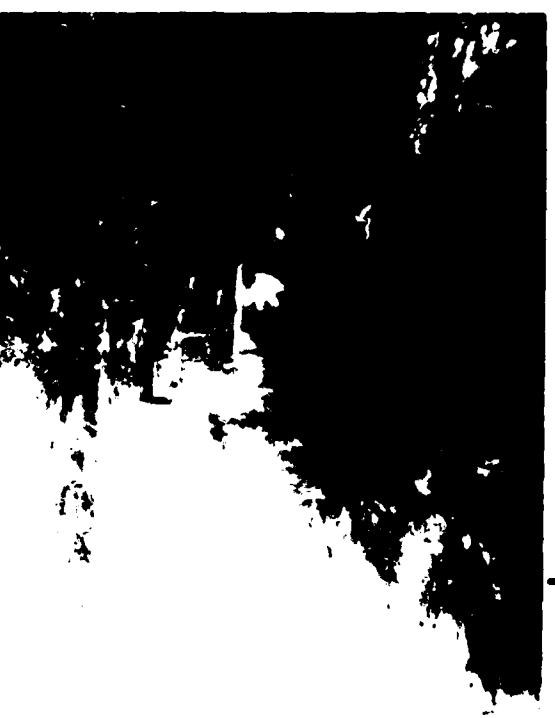
10



12



9



11

APPENDIX D
HYDROLOGIC COMPUTATIONS
WATERSHED MAP

BY T.I.C. DATE July 18 PROJECT Army Corps Engineers SHEET NO. 1 OF 4
CHKD. BY DATE Dam Inspection - Tower Hill Reserv. JOB NO. 8-086

Tower Hill Reservoir Dams

I. Hydrologic & Hydraulic Analysis

a) Drainage Area = At Dam site, the drainage area is about 12.5 sq. miles includes Debes Pond and its drainage area.

b) Watershed Characteristics

Main channel slope = 0.0065

Except the small area at Tower Hill, the watershed generally relatively flat with lots of wet beds and wooded area, therefore, it can be classified as flat basin, at present.

c) Water surface area = 210 acres at elevation of 322 ±.

d) Storage Capacity = 1300 M.G. = 4500 acres between the bottom of Lower Res. to Elev. 322 ± MSL. Based on storage and the size of the basin, it should belong to intermediate category

e) P.M.F. peak = 700 cfs/sq. mile
= 2750 cfs

f) Spillway Design Capacity = Based on records, there were several design flood flows, but did not indicate which was the final designed flow.

Wave Height = $0.17\sqrt{F} + 2.5 - \frac{F}{2}$
Using 80 mile per hr wind velocity and with a direct length of water surface of about 0.25 fetch

Wave height = $.76 + 2.5 - .71 = 2.55 \text{ ft}$ use 2.5'

Top of Dam at El. 325.95, Crest of Spillway at El. 320.95

WHITMAN & HOWARD, INC.
45 WILLIAM STREET, WELLESLEY, MASS.
Engineers and Architects

BY T.T.C. DATE July 28 PROJECT Army Corps of Engineers
 CHKD. BY DATE Dam Safety Inspection - Tower Hill Dam SHEET NO. 2 OF 4
 JOB NO. 2-286

Gross Freeboard = 5 ft
 So, $H = 2.5$ ft

$$\text{Spillway Capacity} = 3.7 \times 250 \times (2.5)^{1.5} \\ = 3656.4 \text{ cfs} < 1/2 \text{ PMF}$$

Neglecting Wave effect, the spillway maximum capacity
 $= 3.7 \times 250 \times 5^{1.5} = 10342 \text{ cfs} > \text{PMF}$

Discharge Rating Curve on Page 4

g) Consider Surcharge Storage Effect.

$$H_1 = \left(\frac{QPI}{3.7 \times 250} \right)^{0.6667} = 4.46 \text{ ft}$$

$$\text{STOR}_1 = 4.46 \times 12 \times 210 \times 0.001563 / 12.5 \\ = 1.4 \text{ inch}$$

$$QPI = QP1 \left(1 - \frac{1.4}{19} \right) = 87.0 \times 0.926 = 80.59 \text{ cfs}$$

$$H_2 = \left(\frac{QPI}{3.7 \times 250} \right)^{0.6667} = 4.23 \text{ ft}$$

$$\text{STOR}_2 = 4.23 \times 1.4 / 4.46 = 1.33 \text{ "}$$

$$\text{STOR}_{\text{Ave}} = \frac{1.33 + 1.4}{2} = 1.36 \text{ "}$$

$$QP3 = QPI \left(1 - \frac{1.36}{19} \right) = 80.75 \text{ cfs}$$

$$H = \left(\frac{80.75}{3.7 \times 250} \right)^{0.6667} = 4.24 \text{ ft}$$

$$\text{Required Gross Freeboard} = 4.24 + 2.5 \\ = 6.74 \text{ ft}$$

e) Conclusion:

The Tower Hill Reservoir Dam and its spillway and the intake conduits would be safe in new PMF including wave height consideration, but PMF not inclusive.

BY T.T.C. DATE July 78 PROJECT Army Corps Engrs. SHEET NO. 3 OF 4
CHKD. BY J.E. DATE Aug. 78 Dam Engr. - Tower Hill Res. JOB NO. E-081

Because this reservoir is near N.H.'s largest city, development in the drainage area in the future is likely. The changing of watershed characteristics would increase the runoff. Spillway design flow equal to M.P.F. would be ideal.

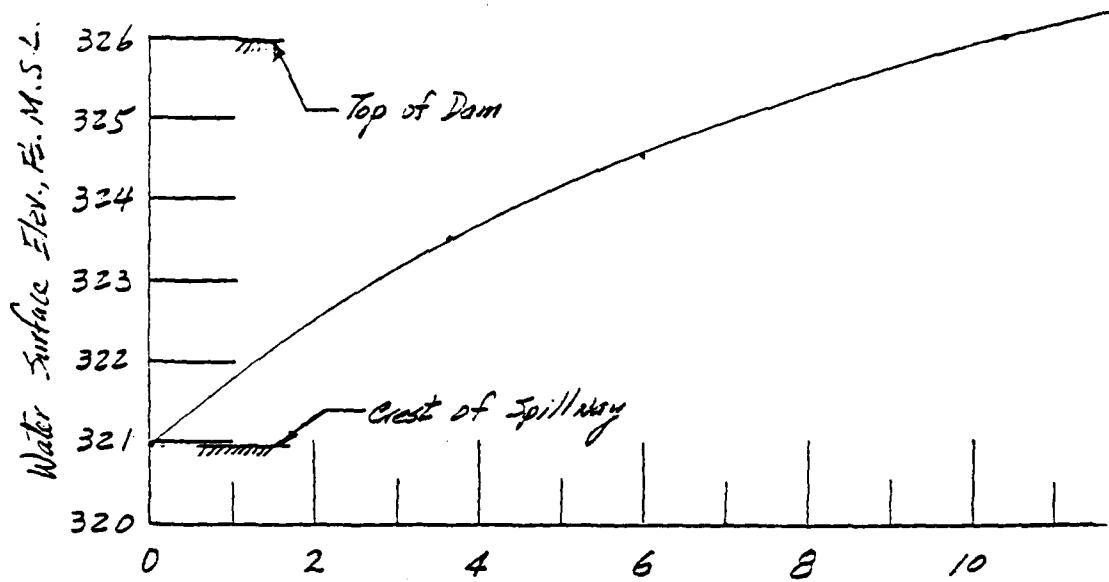
If wave damage is to be prevented, one way would be to raise the top of dam by one foot and to raise the existing stone wall to elev. 325 for wave protection.

Intake structure may remain as it is. Wave action would probably not damage the gate house.

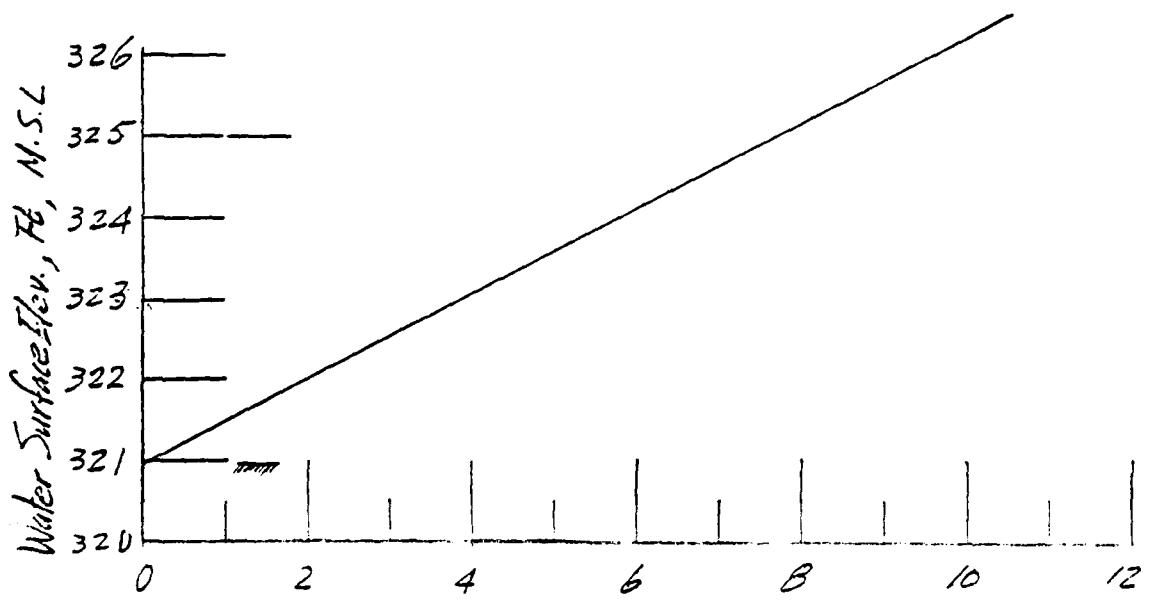
II. Other Conclusions:

- a). There is a small leak under the spillway; pressure grouting may be needed.
- b). Downstream of the spillway has loss of grout, and some of the area does not show any riprap protection. Though it is at a low head, protection from erosion still desirable.
- c). The grade of top of dam is not as even as it should be. Part of the wave protection wall has gone. Repair is necessary.
- d). Riprap is fair condition, but size of the stone is smaller than it should be by today's standards.
- e). Downstream face generally in fair to good condition. Two surface erosion lines have been found near the gate house. It should be refilled, loaned, and seeded.

BY T.I.C. DATE 4/27/72 PROJECT Army Corps Engineers
CHKD. BY _____ DATE _____ SHEET NO. 4 OF 4
Dam Safety Inspection - Tower Hill Res. JOB NO. 8-085

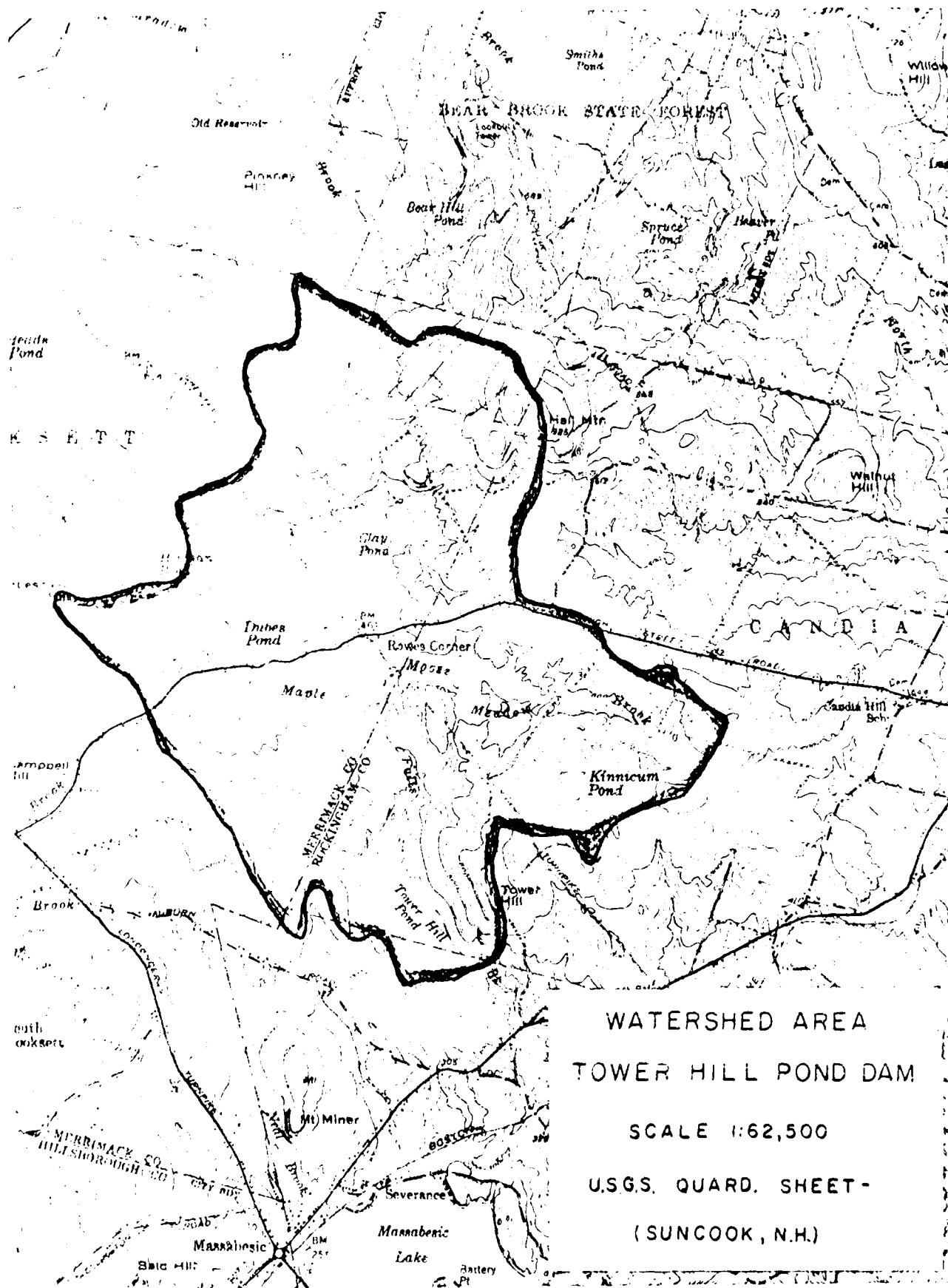


Discharge Flow Rate in thousands C.F.S.
DISCHARGE RATING CURVE



Surcharge Storage Capacity, Thousands acre-ft.
SURCHARGE STORAGE CAPACITY CURVE

WHITMAN & HOWARD, INC.
45 WILLIAM STREET, WELLESLEY, MASS.
Engineers and Architects



WATERSHED AREA

TOWER HILL POND DAM

SCALE 1:62,500

U.S.G.S. QUARD. SHEET -

(SUNCOOK, N.H.)

APPENDIX E
INFORMATION AS CONTAINED IN
THE NATIONAL INVENTORY OF DAMS

INVENTORY OF DAMS IN THE UNITED STATES

①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩	⑪	⑫	⑬	⑭	⑮	⑯	
IDENTITY NUMBER	DIVISION	STATE	COUNTY	STATE												
219	NED	NH	015	01												

⑯ TOWER HILL POND. DAM ⑯ 4302.0 7121.9 01AUG78

⑯	POPULAR NAME	NAME OF IMPOUNDMENT
⑯	TOWER HILL POND	

⑯	REGION/BASIN	RIVER OR STREAM	NEAREST DOWNSTREAM CITY - TOWN - VILLAGE	DIST FROM DAM (MI.)	POPULATION
⑯	0105	MAPLE FALLS BROOK	AUBURN	2	2035

⑯	TYPE OF DAM	YEAR COMPLETED	PURPOSES	SPILLWAY HEIGHT	HYDRAULIC HEAD	IMPOUNDING CAPACITIES (ACRE-FT.)	OWNER	PRIV/FED	SCA	VER/DATE
⑯	REGPG	1940	8	14	34	1940	NED	N	N	01AUG78

⑯	REMARKS									
---	---------	--	--	--	--	--	--	--	--	--

⑯	⑯	⑯	⑯	⑯	⑯	⑯	⑯	⑯	⑯	⑯	⑯	⑯	⑯	⑯	⑯
⑯	SPILLWAY HAS CREST WIDTH	SPILLWAY DISCHARGE (FT.)	MAXIMUM VOLUME OF DAM (CY)	POWER CAPACITY INSTALLED (MW)	NAVIGATION LOCKS										
⑯	2	1470	C 250	10340	NO	LENGHT (FT.)	WIDHT (FT.)	LENGHT (FT.)	WIDHT (FT.)						

⑯	OWNER	ENGINEERING BY	CONSTRUCTION BY
⑯	MANCHESTER WATER WORKS		

⑯	MANCHESTER WATER WORKS	MANCHESTER WATER WORKS	MANCHESTER WATER WORKS	
⑯	REGULATORY AGENCY	CONSTRUCTION	OPERATION	Maintenance
⑯				
⑯	MAN. WATER RES. BD	NHMRB	NHMRB	NHMRB
⑯	INSPECTION BY	INSPECTION DATE	INSPECTION DATE	AUTHORITY FOR INSPECTION
⑯		DAY MO YR	DAY MO YR	
⑯	WHITMAN AND HOWARD, INC.	05JUL78	PL92-367	REMARKS

END

FILMED

3-85

DTIC